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Validation of Suction Can Foundations for Offshore Wind Structures

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Abstract

A suction can is a large cylindrical structure, which penetrates into the seabed due to self-weight and a suction pressure (see Fig. 1). This foundation type is promising for offshore structures due to some differential advantages in comparison with conventional pile foundations: e.g. environmental friendly installation and decommissioning, lower noise, shorter installation time and the ability to retract the structure in case of a penetration refusal. This poster demonstrates a finite element (FE) analysis of a suction can foundations for offshore wind structures in the German North Sea. It shows that FEM is applicable to fulfill the requirements of the German Maritime and Hydrographic Agency (BSH) for suction cans design.

Fig. 1: Example of Suction Can

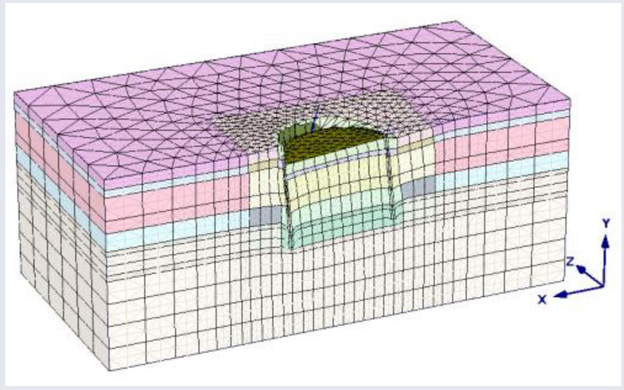

Fig. 2: Mesh of the FE model

Objectives

Installation processes and in-place performance of the suction cans must be taken into account in geotechnical design. The geotechnical analysis should be estimated in consideration of

- three failure modes of sliding, overturning and bearing capacity for stabilities
- the excess pore water pressure accumulation and dissipation in surrounding soil due to cyclic loading
- post installation scouring

subject to BSH requirements.

Methods

Site investigations showed that the soil on site consists of silty sand and loose sand in the upper level and dense sand at levels below. It should be noted that pore water pressure would be generated and dissipated in the silty sand due to cyclic loading of wave, current and wind. A 3D FE model has been developed to verify the geotechnical stability of the suction cans, i.e. sliding, overturning and bearing capacity, by means of the commercial FE method software PLAXIS:

- A 180° model has been developed due to one symmetry axis (see Fig. 2).
- 15-node wedge elements have been used (9,750 elements, 27,792 nodes)
- The Hardening soil model has been used to describe the behavior of soils.
- The shear stress degradation of the soil has been calculated and the degraded interne friction angle has been derived.

The simulation has been executed in three steps:

- A initial stress state was generated by defining vertical stresses according to the overburden height. The initial horizontal stresses were determined by considering the earth pressure at rest, using the earth pressure coefficient at rest K0.
- In the second step, the suction can, the expected degraded soil profile, and the interfaces are activated.
- In the subsequent calculation steps the loads are applied. Post installation scour has been modeled by excavating the surrounding soil over the allowable scour depth. The evaluated characteristic extreme load is increased linearly at the same rate up to model failure.

Results

The load displacement behavior of the soil surrounding the suction can is shown in Fig. 3. The behavior is approximately linear for the first steps, and then plastic. Based on the load displacement curve, the performance of the suction can foundation has been assessed and the global safety factor of the combined bearing, sliding and overturning capacity has been evaluated.

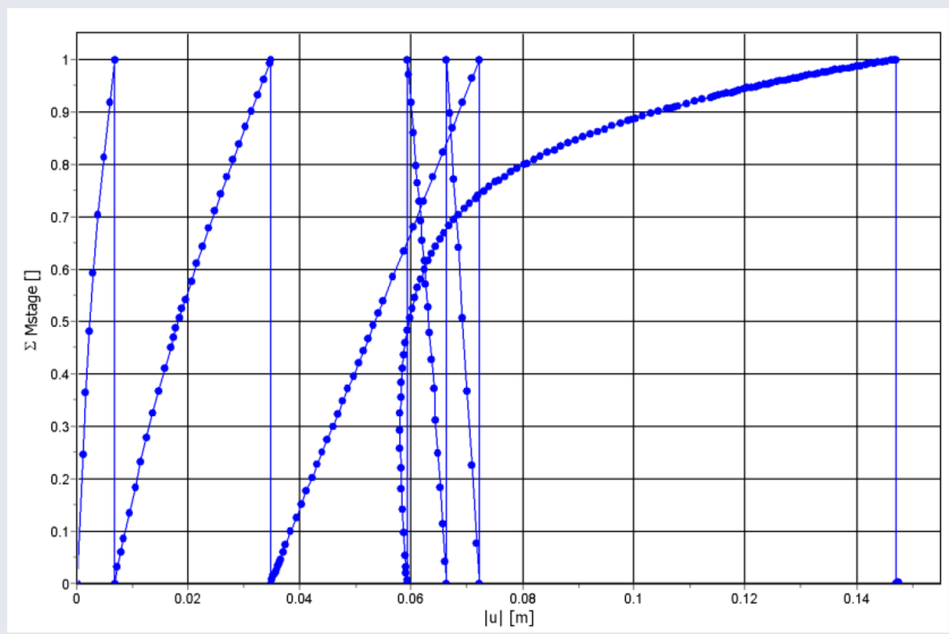

Fig. 3: Load - displacement curve

Fig. 4 presents the total displacement of the surrounding soil. Furthermore, the accumulated rotation has been computed and compared to the tolerable rotation for the offshore structure.

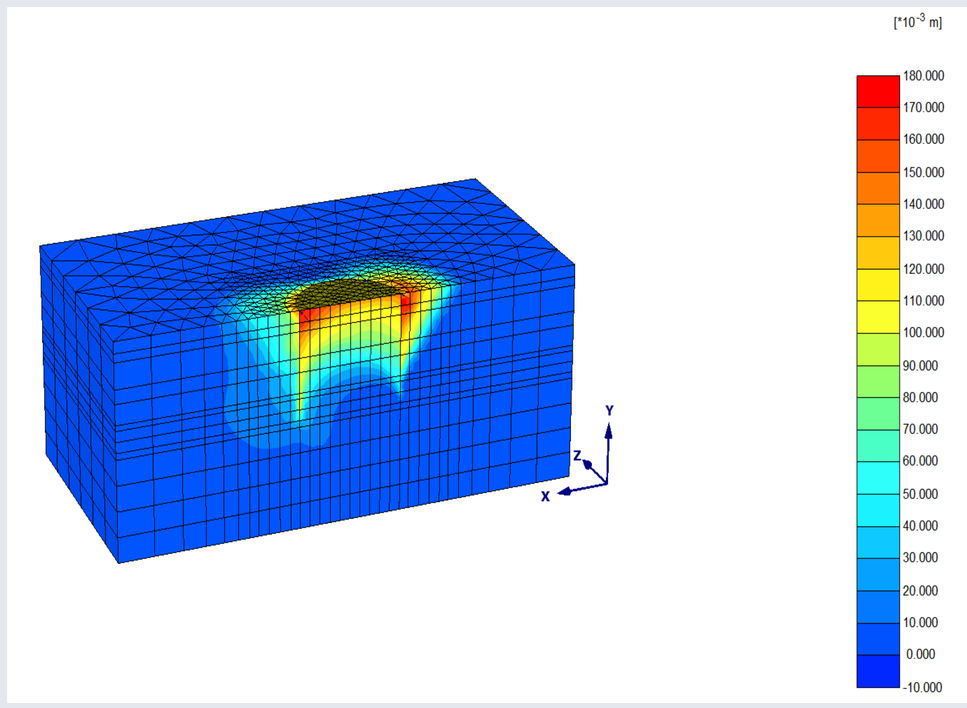

Fig. 4: Contour plot of the total displacement

Conclusions

A validated guideline for the design analysis of a suction can foundation does not still exist. A FE model has been developed for design purpose in consideration of

- three failure modes of sliding, overturning and bearing capacity for stabilities
- the excess pore water pressure accumulation and dissipation in surrounding soil due to cyclic loading
- post installation scouring

The analysis shows that the suction cans stability checks required by German Standards e.g. BSH Standard can be carried out by means of a finite element model based on a sound engineer judgment.

The risk regarding the design, the approval, fabrication and installation costs of suction can foundations can be well controlled. It shows that, suction cans could be a promising, economic and environmental friendly foundation option for the offshore wind industry.